SINGLE STAGE GLOBAL STABILIZATION FOR SUBAXIAL CERVICAL SPINE INJURIES

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CERTIFICATE

This is to certify that the dissertation titled **"SINGLE STAGE GLOBAL STABILIZATION FOR SUBAXIAL CERVICAL SPINE INJURIES"** is the original work done by ***Dr.D.R.RAMPRASATH,*** post graduate in M.S., Orthopaedic Surgery at the Department of Orthopedic Surgery, Madras Medical College, Chennai-600 003 to be submitted to the Tamil Nadu Dr. M.G.R. Medical University, Chennai- 600 032, towards the partial fulfillment of the requirement for the award of M.S., Degree in Orthopaedic Surgery, March 2008.

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CONTENTS

INTRODUCTION

Cervical spine injuries are one of the common causes of serious morbidity and mortality following trauma. 6% of trauma patients have spine injury of which >50% is contributed by cervical spine injury (Rockwood & Green[29]).

Early recognition, immobilisation, preservation or restoration of spinal cord function, and stabilisation are the keys to successful management of patients with cervical spine injuries.

Cervical instability due to trauma is usually from the level of C3 to C7 (i.e. subaxial). Neurological deficits are not uncommon i.e.. root compression and cord compression with subluxation or dislocation.

Unstable cervical spine injuries with or without neurological deficit require open reduction.

Stabilisation is done by using various implants and bone grafting. Implants provide immediate stability, whereas bone grafts provide long term stability by achieving intervertebral fusion.

For any fracture in various bones of the body, fixation in polyaxial planes is proven to provide better stability than those done in single plane. Same principle is applied to cervical spine injuries. Both anterior and posterior stabilisation provides better stability than either one alone.

The procedure of global stabilization(called as "circumferential arthrodesis" by McAfee and Bohlman[23]) can be done in two stages or in single stage.

We have done the procedure in single stage for all our cases under study.

AIM OF THE STUDY

To evaluate

- Applicability
- Safety
- Radiologically observed efficacy
- Functional outcome

of the procedure.

HISTORICAL REVIEW

1550 BC	Egyptians in the Edwin Smith Payrus considered acute neck injury as “an ailment not to the treated”[18].
460-377 BC	Hippocrates introduced the methods of traction in prone position for treating spinal injuries[18].
1672	Hildanus - First to introduce the technique for reducing fracture dislocation of cervical spine[18].
1700-1780	Paul of Agenda[19] suggested surgical excision of fractured spinous processes for treating traumatic spinal disorders.
1809	Malgaigne[18] said all spinal fractures resulted in paralysis.
1856-1904	Chipault[18] - a French surgeon published the first textbook on spinal surgery presenting the most complete survey of past & current spinal surgery.

	The specialist year book “Travaux de neurologic churgicale”, first neurosurgical journal in the world.
	In 1904, he published, “Manual de orthopedic vertebrale”, which primarily dealt with the orthopedic treatment of spinal disorders.
	First to describe transoral approach.
1866-1945	Sudeck explained how to radiograph the spine methodically[18].
1877	Bouterou - first to reduce fractures with weight attached by adhesive tape to the patient’s face[18].
1925	John Davis - first usable lateral radiograph of the spine[18]
1928	Stuckey approached the cervical spine anteriorly for a chordoma[18]
1929	Taylor introduced head-halter traction[18]
1933	Crutchfield introduced head holding tongs[18]
1958	Cloward the disc - introduced the anterior approach for degenerated disc[6]

Cloward-Anterior arthrodesis using a cylindrical dowel of iliac crest graft.

1960 Bailey & Badgley described the method of anterior cervical fusion of the traumatic cervical spine using iliac crest graft[3]

1962 Robinson - Anterior arthrodesis using horse-shoe shaped iliac crest graft[27]

1964 Roy Canille in France - First to insert screws in lateral mass to stabilise unstable spine. Magerl in Switzerland followed him[1]

1966 Simmonds - used a keystone shaped graft for anterior cervical fusion[8]

1970 Orosco & Llovet - first to secure a bone chip with a plate, for fractured cervical spine[8].

1976 Whitcloud & La Roca - use of cortical fibula[14].

Senegass & Gauzere[14]- introduced H-plate for AO/ASIF

1986 Caspar plates introduced

1990	Orion plates with locking nuts introduced.
1991	Zdeblick - used freeze dried allograft bone (iliac crest) for anterior cervical fusion[38].
1994	Pintar - used hydroxyapatite for fusion of cervical spine[14]
1996	Shapiro used banked fibula and the locking anterior cervical plate for anterior cervical fusion[31]
1999	Melca - use of bovine bone(xenograft) with anterior cervical plate for anterior cervical fusion[25].
	Majid - used titanium mesh cages with autografts and anterior plates for anterior arthrodesis[14].

ANATOMY

DEVELOPMENTAL ANATOMY OF CERVICAL SPINE:

Antenatal Development:

During third week of intrauterine life, development of mesoderm on either side of neural tube and the notochord becomes aggregated to form SOMITES. Somites differentiate into ventromedial part (the sclerotome) and dorsolateral part (the dermatomyotome). During fourth week, selerotome forms the vertebrae, ribs and spinal ligaments, while the dermatomyotome forms the musculature and dermis of scalp, neck & trunk.

The cranial half of first cervical selerotome fuses with the caudal portion of fourth occipital somite to form basilar portion of occipital bone. Caudal half of first cervical selerotome fuses with cranial half of second cervical selerotome to form first cervical vertebra. The same type of fusion is repeated down the length of cervical spine.

Postnatal development:

Ossification centers in lateral masses that expand into posterior arches join by about 3 years of age. A secondary

ossification centre develops in the anterior arch of the cervical vertebra by one year of age. It fuses with the lateral masses by 6 to 9 years.

Clinical Anatomy:

Vertebral column is made of 5 parts viz., cervical, thoracic, lumbar, sacral & coccygeal parts. Cervical spine consists of 7 vertebral, first two of which Atlas & Axis are atypical. C3 to C7 are typical.

Typical Cervical Vertebrae (Fig.1):

They are structured to provide limited flexion, extension, tilt and rotation as well as to provide stability to support the head. Vertebral bodies have a superior surface, which is convex anteroposteriorly and concave laterally. This configuration allows flexion, extension, lateral tilt by gliding movements of facets. Inferior surface of vertebral body is convex. Lateral aspect of body has superior projection called uncinate process.

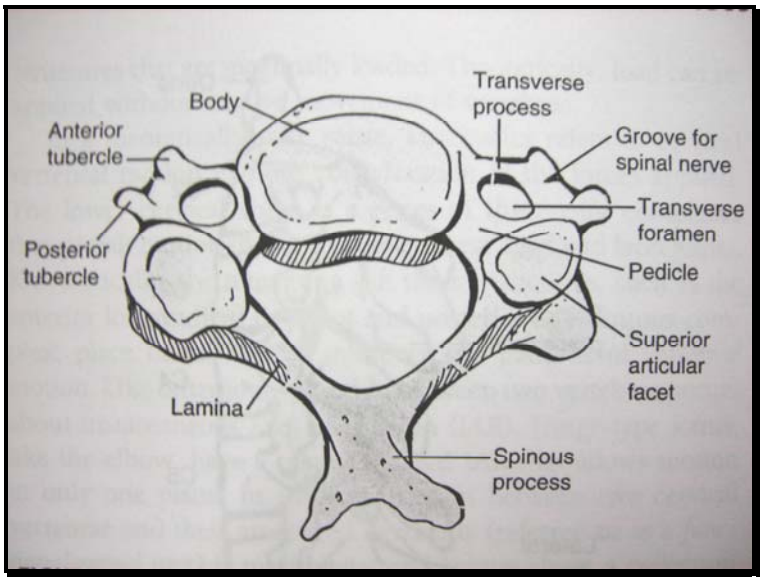
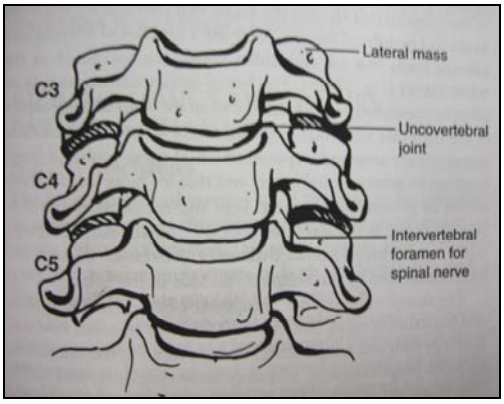


Fig-1: Typical Cervical Vertebra

The lamina and spinous process of C2 are the largest, whereas C3, C4 & C5 have thin laminae to help assume the normal lordotic posture. The spinous processes of third, fourth and fifth cervical vertebrae are bifid. The laminae of sixth and seventh cervical vertebrae become progressively thickened and larger to approach the size of thoracic vertebrae. The facetal joints are placed in a coronal plane angled 45^0 to the horizontal. Due to this 45^0 inclination, lateral tilt is accompanied by rotation and vice versa. The gliding motion of the facets allows flexion, extension and lateral tilt.

ANATOMY OF LATERAL MASS(FIG.2,3):

The morphology of the cervical lateral or articular mass has been described by Roy Camille et al., Pait et al and Ebrahim et al. The lateral mass consists of superior and inferior facets. The area of the lateral mass is the part lateal to the lamina and between the inferior margins of adjacent inferior facets. The mean superoinferior diameters of the lateral mass range from 11 mm at C3 to 15mm at C7, and mean mediolateral diameters range from 12 to 13mm at C3 through C7. The mean antero-posterior diameter of the lateral mass is smaller at C6C7 levels than at levels above[10].



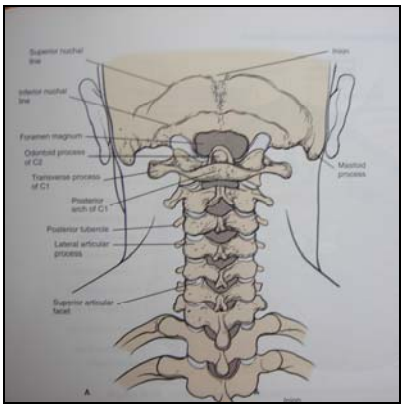


Fig.2&3: Anterior View & Posterior View

In the transverse plane, the transverse foramen lies anteromedial to the posterior centre of lateral mass at the levels of

C3 to C5. At C6, it courses laterally, and lies infront of the posterior center of lateral mass[11].

THE SPINAL NERVE (FIG.4):

Spinal nerve exiting the spinal canal passes through the interpedicular foramen. Laterally in the intertransverse foramen, it divides into a large ventral ramus and a smaller dorsal ramus. The ventral ramus of the cervical spinal nerve courses on the transverse process in the anterolateral direction to form the cervical and brachial plexus.

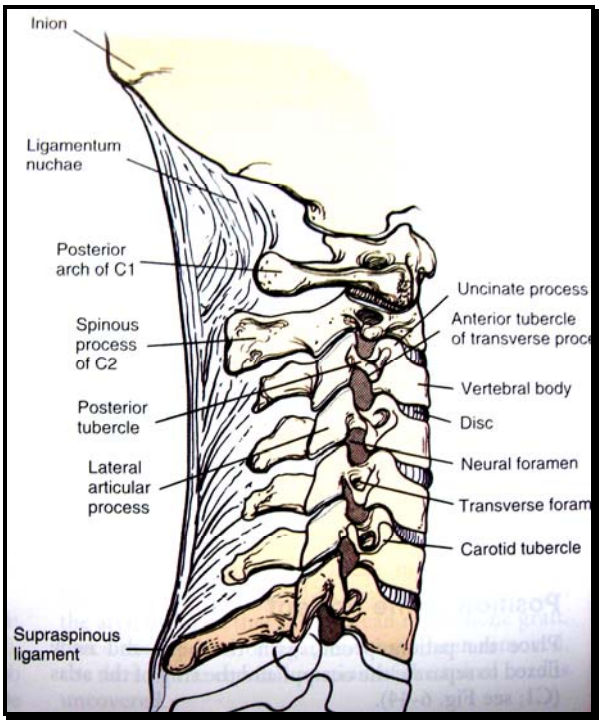


Fig-4: Lateral View

On the oblique sagittal images, the cervical nerve root is located in the lower part of the interpedicular foramen and occupies the major inferior part of the intertransverse foramen. On the posterior aspect of the lateral mass, the mean distance is about 5.6 mm from the posterior centre of the lateral mass to the projection of the spinal nerves superiorly and inferiorly for all levels. Pait et al[4] divided the lateral mass into 4 quadrants, and found that the superolateral quadrant is away from the spinal nerve. On the transverse sections through the upper portion of the superior articular process, the spinal nerve either does not appear, or when it does, it is situated anteromedially to the anterior aspect of the superior facet. On transverse sections through the lower portion of superior articular process, the contour of the spinal nerve is best delineated, where it is still situated anteromedially or anteriorly to the anterior aspect of the superior facet and courses in the anterolateral direction. On the transverse section through the pedicle, the spinal nerve lies anterolateral to the lateral mass and is separated by the posterior ridge of the transverse process. The C7 spinal nerve is relatively larger and closer to the anterior aspect of the lateral mass due to its more posterior course in the transverse plane.

THE VERTEBRAL ARTERY (FIG.5)**:**

Vertebral artery originates from the subclavian artery, enters the transverse foramen of the sixth cervical vertebra, and courses upward through the foramen above. On the transverse plane, the vertebral artery lies infront of the lateral mass, but is separated by the spinal nerve.

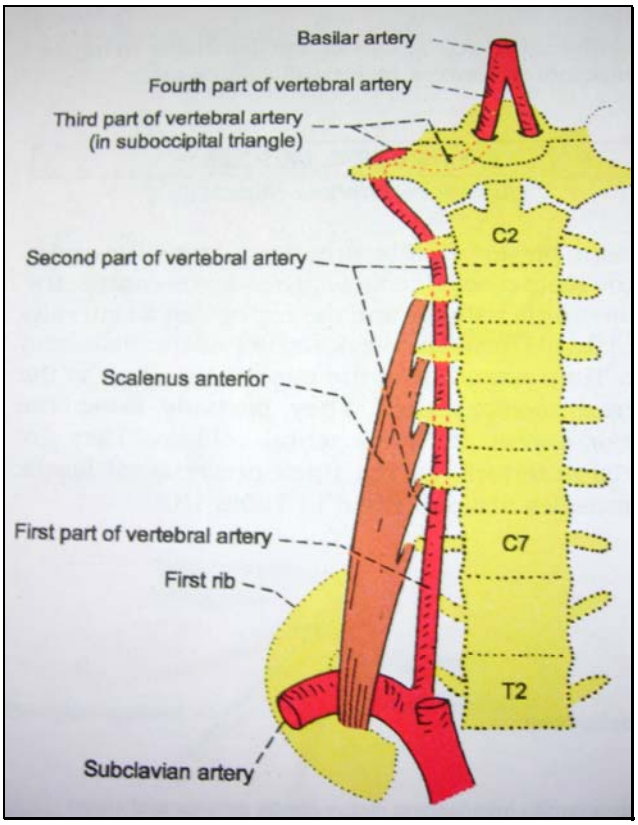


Fig.5 Vertebral artery

Applied anatomy of anterior approach to cervical spine:

Landmarks in the neck[15] (Fig.6)

- Hard plate – arch of atlas
- Lower border of mandible - C2 C3
- Hyoid bone - C3
- Thyroid cartilage - C4 C5
- Cricoid Cartilage - C6
- Carotid tubercle - C6

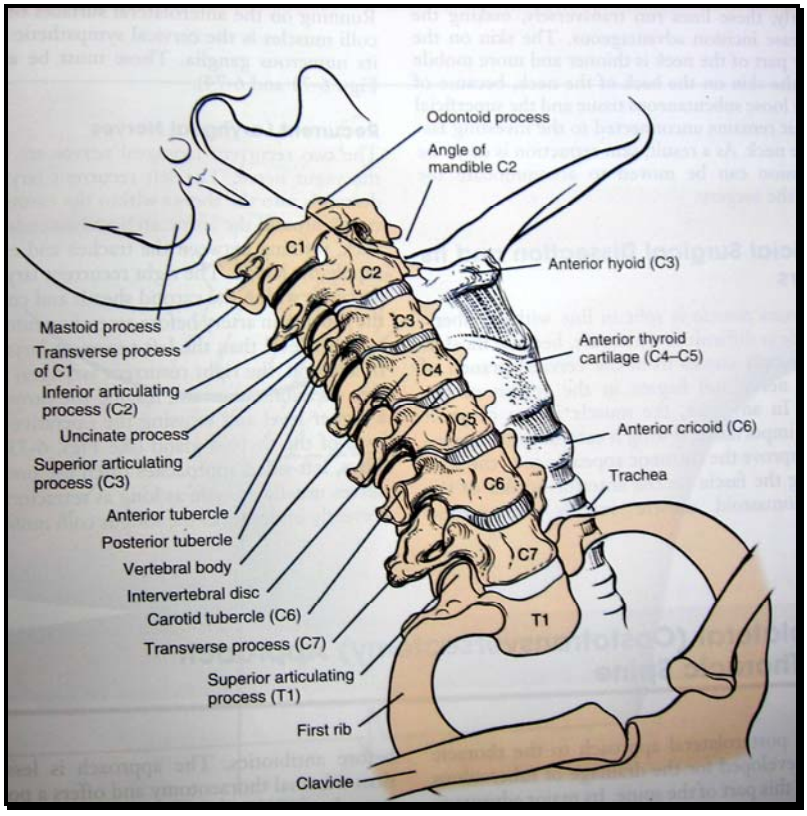


Fig 6: Anatomical Landmarks

FASCIAL LAYERS IN THE NECK[13] (FIG.7)**:**

1) Investing layer of deep cervical fascia - envelops sternocleidomastoid & trapezius muscles.

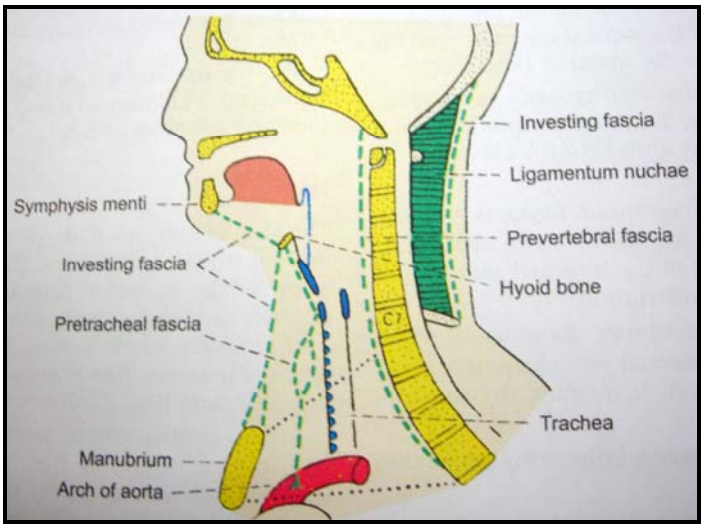


Fig.7 Fascial layers of neck

2) Pretracheal fascia - invests the strap muscles. It is related to the carotid sheath. Superior & inferior thyroid vessels run from the carotid sheath through the pretracheal fascia into midline. These may be divided to enlarge exposure.

3) Prevertebral fascia – It lies infront of prevertebral muscles,and forms the floor of posterior triangle of neck.

RECURRENT LARYNGEAL NERVES:

They are branches of vagus nerve. The left nerve descends into thorax within the carotid sheath. It curves around aortic arch, and ascends back in the neck between trachea and esophagus. The right nerve descends within the carotid sheath and curves around subclavian artery and ascends into the neck at a higher level than the left nerve .So left sided approach are preferred.

Carotid sheath:

It contains carotid vessels, internal jugular vein, and Vagus nerve.

BIOMECHANICS OF LOWER CERVICAL SPINE

KINEMATICS OF CERVICAL SPINE:

In spinal kinematics, the motion is usually described in relation to adjacent vertebra. The secondary coordinate system may be established in the body of adjacent vertebra.

The most detailed and convincing work on kinematics of cervical spine was done by White & Punjabi. The spine is a mechanical structure. The vertebrae articulate with each other in a controlled manner through a complex of levers (vertebrae), pivots (facets & discs), passive restraints (ligaments) and activators (muscles). The major portion of mechanical stability of spine is due to highly developed, dynamic neuromuscular control system.

STRUCTURES ALLOWING MOTION:

The sub axial (below C2) spine contributes approximately 50% of flexion - extension and rotation of cervical spine. The orientation of posterior facet joints (45^0 angle in the coronal plane) allows for more mobility than is possible in the other spine regions. Motion at the facet joints is also complemented by concomitant motion between vertebral bodies through the intervertebral discs. The

uncovertebral joint, not a true diarthrodial joint also contributes to cervical mobility.

STRUCTURES RESISTING COMPRESSION & DISTRACTION (FIG.8):

Compressive forces applied in an axial mode are supported or resisted by the vertebral body, the intervertebral disc, the uncovertabral joints of anterior and middle columns, and the facets and lateral masses of posterior columns. The result is a tripod of support made up primarily of the vertebral body and two lateral masses with associated facet joints.

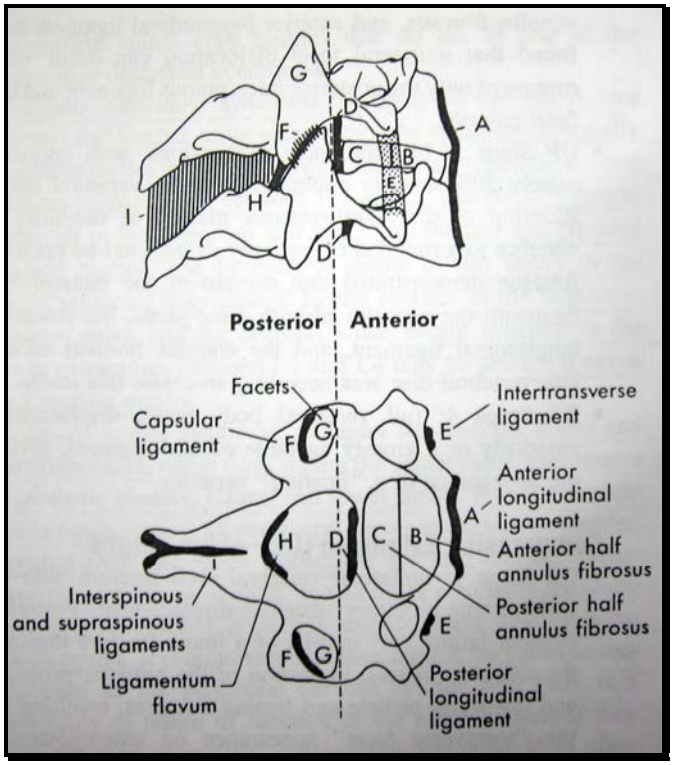


Fig.8 Ligamentous attachments

The ligaments of the cervical spine function primarily to provide resistance to distractive forces. Distraction of the anterior column is limited by anterior ligamentous complex, and posterior column by posterior ligamentous complex.

STRUCTURES LIMITING MOTION:

Because movement of neck places both compressive and distractive forces on the cervical spine, both bony & ligamentous structures assist in limiting motion. During flexion, compression occurs in anterior column, distraction occurs in posterior column. Flexion is therefore limited by vertebral body, intervertebral disc and posterior ligamentous complex. Likewise extension places compressive forces on posterior column and distractive forces on anterior column. Resistance to extension is therefore provided by lateral mass or facet complex and anterior ligamentous complex. Lateral flexion to one side is limited by contralateral facet capsule and annulus fibrosus and by ipsilateral vertebral body and lateral mass or facet complex.

RANGE OF MOTION:

Flexion and extension are free and tends to be greater at C5 C6 & C6C7 interspace where they total 17 degree and 16 degree

respectively. Lateral bending and rotation are most free at C3C4 & C4C5 levels where they total 11 degree. Neck movements diminishes with age. Forward flexion should normally allow chin to touch the chest. Extension can sometimes allow skull to touch the back. In lateral flexion, ear should touch the shoulder.

IMPLANTS

ANTERIOR CERVICAL PLATES:

1. Unconstrained systems - include Caspar plates & H-plates[2] (Fig.9) - no locking facility.

2. Constrained systems - include Orion plates & cervical spine locking plates (CSLP) - locking of plate to screw is possible.

Anterior Cervical cages:

1. Titanium mesh cage
2. Titanium cylindrical threaded cage
3. Stainless steel cages
4. Carbon fibre cages

Posterior Instrumentation:

1. Interspinous wirings.
2. Lateral mass fixation with one-third tubular plates.
3. Lateral mass fixation with recon plates[2] (Fig.10).

Fig.9: Recon Plate

Fig. 10: H-Plate

CERVICAL SPINE INSTABILITY

Stable injury involves only one column, whereas unstable injury involves both columns.

White & Punjabi[5] defined instability as the loss of ability of spine under physiologic loads to maintain relationships between vertebrae in such a way that there is neither damage nor subsequent limitation to spinal cord or nerve roots. Clinical instability can be defined as any interruption in normal smooth translation of vertebral biomechanics as evidenced by jerky or excessive spinal movements.

WHO SCORING SYSTEM

S.No	*Score card for clinical instability*	*Points*
1.	Positive stretch test	20
2.	Spondylosis or degenerative disc disease developing within 3 years of injury	20
3.	Plain film evidence of instability	15
4.	Video Fluoroscopic evidence of instability	15
5.	Any documented clinical spine fractures	15
6.	Spinal cord or nerve root irritation subsequent to injury	15
7.	Initial neurologic symptoms lasting longer than one week	05
8.	Intractable pain resulting from injury	05
9.	Spondylolysis or degenerative disc disease present at time of injury	05

- > 30 means definite clinical instability.
- >20 means instability probable
- 10-20 means clinical instability possible.
- <5 means clinical instability unlikely.

Checklist for diagnosis of clinical instability (Fig.11, Fig.12):

S.No	*Element*	*Point value*
1.	Anterior element destroyed or unable to function	2
2.	Posterior element destroyed or unable to function	2
3.	Relative sagittal plane translation >3.5mm	2
4.	Relative sagittal plane rotation >11 degree	2
5.	Positive stretch test	2
6.	Cord injury	2
7.	Root Injury	1
8.	Abnormal disc narrowing	1
9.	Congenital spinal stenosis	1
10.	Dangerous loading anticipated	1
		>5 = Clinical instability

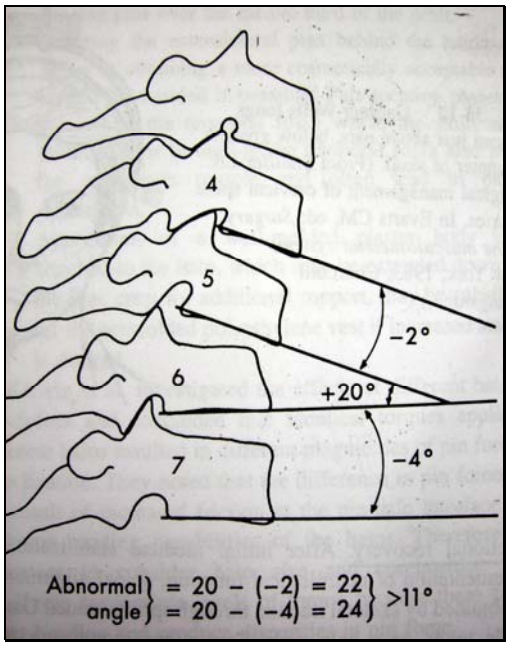


Fig.11: Sagittal angulation

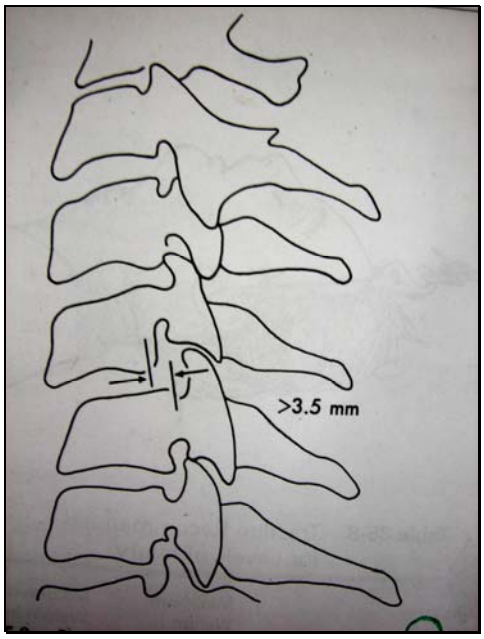


Fig.12: Sagittal Translation

CLASSIFICATION

General Classification of lower (i.e.subaxial)cervical spine injuries –

1. Posterior column injuries
    a) Isolated fracture of posterior elements
        i. Spinous process
        ii. Lamina
        iii. Transverse process
    b) Posterior ligamentous injury
        i. Mild
        ii. Severe
    c) Hyperextension injury with spinal cord injury

2. Facet Injuries
    a) Isolated facet or pedicle fractures
    b) Unilateral facet dislocations
        i. Unilateral facet dislocation
        ii. Unilateral facet fracture with subluxation
        iii. Fracture separation of lateral mass
    c) Bilateral facet dislocation

i. Bilateral facet dislocation

ii. Bilateral facet fracture with dislocation

iii. Bilateral facet fracture dislocation with traumatic disc herniation, distraction injury.

3. Anterior column injury

a. Vertebral body compression fracture

b. Vertebral body compression fracture with posterior ligamentous injury.

c. Discoligamentous extension injury

d. Extension teardrop fracture

e. Traumatic retrolisthesis

f. Stable burst fracture

g. Unstable burst fracture

h. Flexion teardrop fracture

ALLEN ETAL MECHANISTIC CLASSIFICATION [29]:

a. Compressive Flexion (CF)(Fig.13)

Stage I Blunting of anterosuperior vertebral body margin.

Stage II Beak appearance of the anterosuperior vertebral body margin

Stage III Oblique primary fracture line that extends from the anterior vertebral body to the inferior end plate, so called tear drop fracture.

Stage IV Stage III & Posterior translation of upper vertebra measuring <3mm.

Stage V Posterior translation of upper vertebra measuring >3mm, facet gapping, indicating anterior and posterior ligamentous injury.

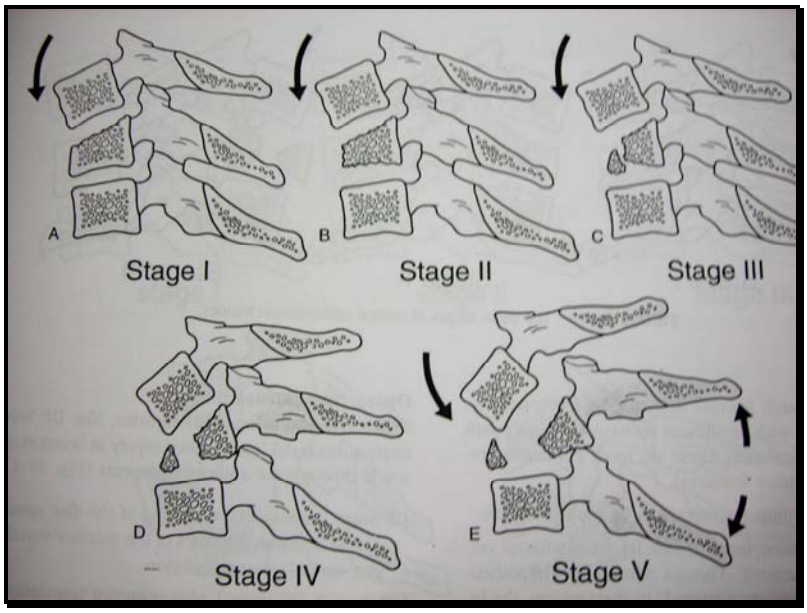


Fig.13: Compressive Flexion

b. Vertical compression (VC)(Fig.14)

Stage I Central superior or inferior end plate fracture

Stage II Superior and inferior end plate fractures

Stage III Vertebral body comminution, with or without retropulsion of fragments, with or without Kyphotic or translational deformity.

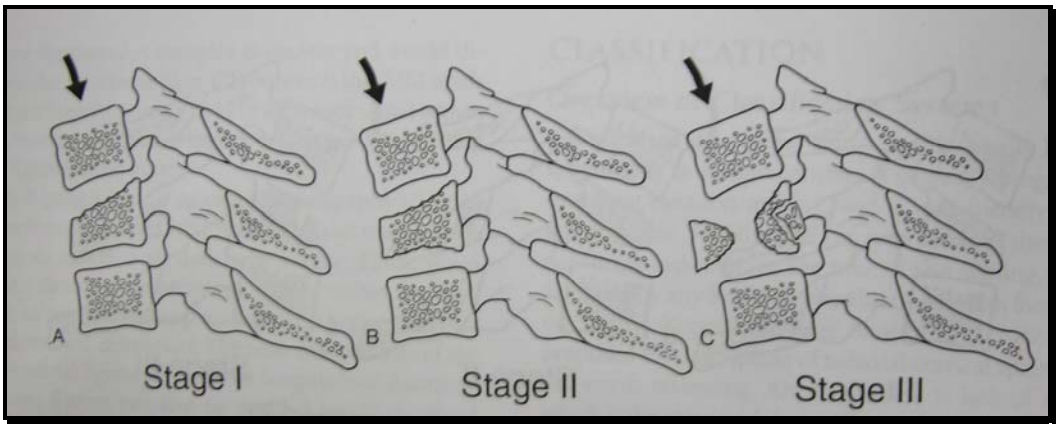


Fig.14: Vertical Compression

c. Distractive flexion (DF) (Fig.15)

Stage I Facet subluxation, gapping of spinous process ligaments.

Stage II Unilateral facet dislocation

Stage III Bilateal facet dislocation, 50% translation of upper vertebral body on lower one.

Stage IV Close to 100% translation of upper vertebral body on lower one, so called floating vertebra.

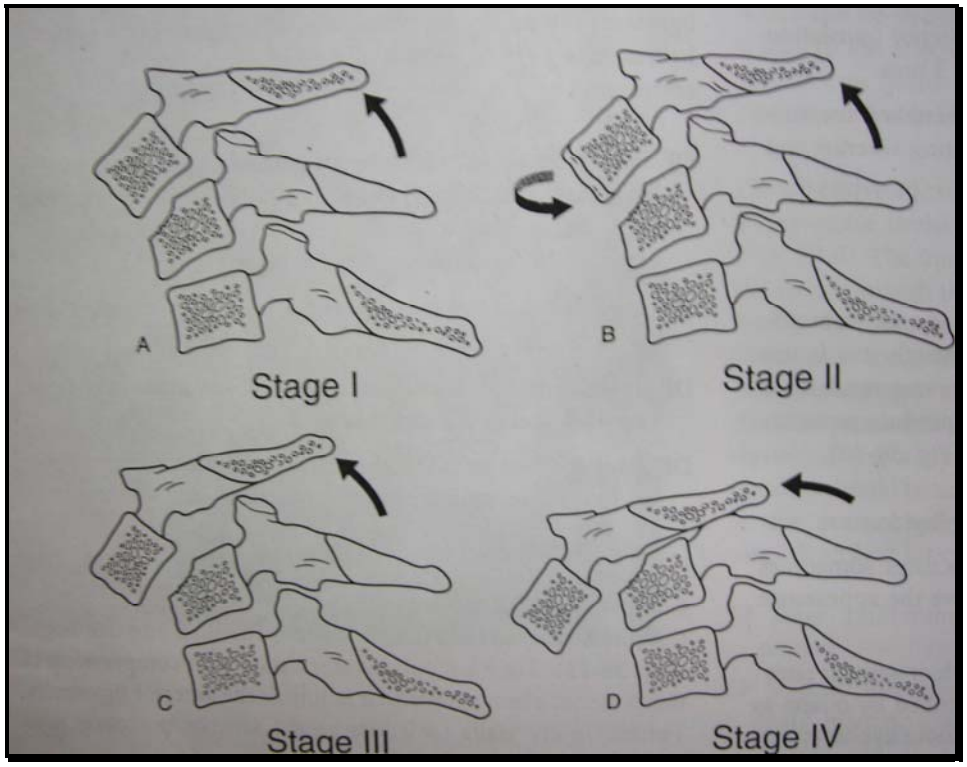


Fig.15: Distractive Flexion

d. Compressive Extension (CE) (Fig.16)

Stage I Posterior arch fracture that may be facet, pedicle or lamina fracture, with or without rotation

Stage II Bilateral lamina fractures, can be multiple levels

Stage III Bilateral lamina, pedicle, facet fractures without vertebral body displacement, so called floating lateral mass fractures.

Stage IV Stage III & partial anterior vertebral body displacement

Stage V Stage III & 100% anterior vertebral body displacement

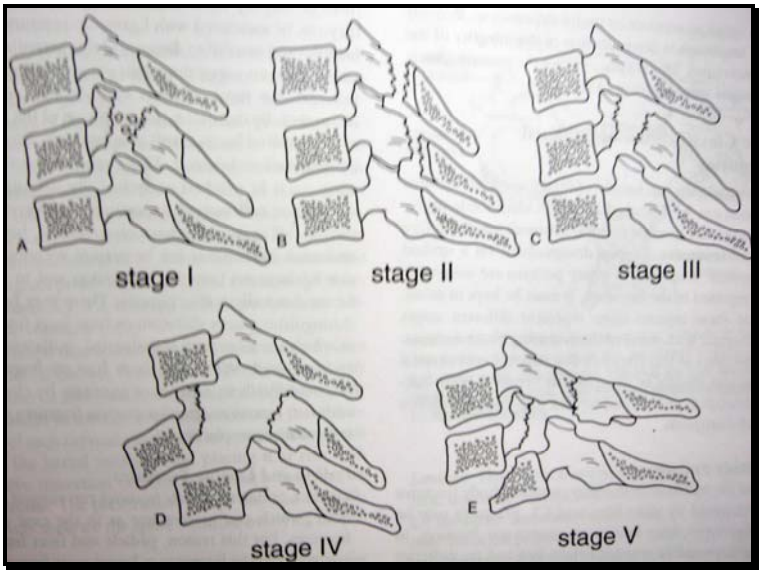


Fig.16: Compressive Extension

e. Distractive extension (DE) (Fig.17)

Stage I Abnormal widening of anterior disc space

Stage II Stage I & Posterior translation

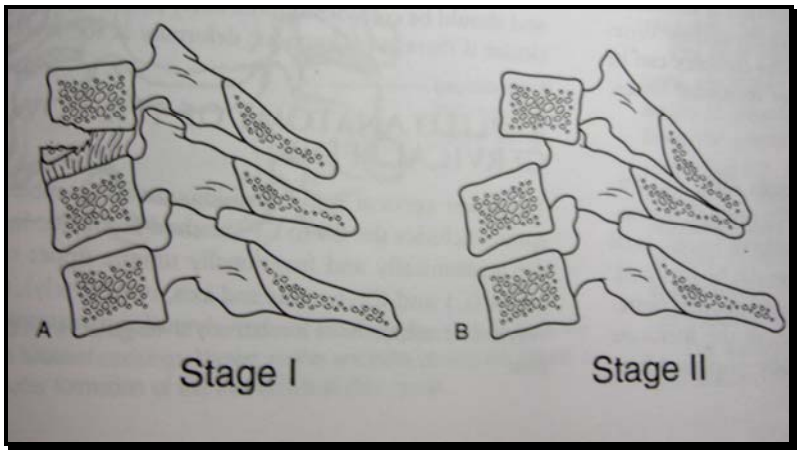


Fig.17: Distractive Extension

f. Lateral flexion (LF)

Stage I Unilateral uncovertebral fracture or asymmetric vertebral body compression.

Stage II Vertebral body or posterior arch fractures with lateral translation or unilateral facet gapping, coronal angular deformity is noted on an AP X-ray.

INVESTIGATIONS

The assessment of cervical spine instability begins with basic physical examination. Similarly, imaging of the cervical spine should begin with basic conventional tomography. CT & MRI should be reserved for appropriate radiographic and clinical examination.

RADIOGRAPHY:

AP View - Recognised structures include vertebral bodies, superior and inferior end plates, disc spaces, uncinate processes, which, together with the inferolateral aspect of the supradjacent vertebral body can be seen.

Lateral view - recognized structures include vertebral body, disc spaces, U-shaped transverse process superimposed on the vertebral body, articular masses, adjacent facets, interfacetal joint, lamina and spinous processes.

Pull down lateral view - demonstrates:

1) C7T1, Apophyseal joints
2) Superior end plate of T1
3) Anterosuperior aspect of body of T1

4) Cervicothoracic prevertebral soft tissue shadow

Swimmer’s view - taken in a position of arms similar to the Australian free style swimming stroke position. It gives osseous superimposition & typically seriously obscures visualization of the middle and posterior columns of the C7 vertebra.

Trauma oblique view - taken in which the cassette is placed as far as possible posterior to the shoulder, neck and head without moving the supine patient. X-ray tube is placed to the opposite side centered on the thyroid cartilage and angled at 35^0. This is repeated on the contralateral side. It gives slightly distorted view by magnification. It is useful in patients with short neck, requires no patient movements or co-operation and demonstrates the posterolatral aspects of C7 vertebra.

Right & left oblique view - shows posterolateral aspects of vertebral body, pedicle, and intervertebral foramen.

CT scan - Shows the body of the dislocated vertebra anterior the uncinte process and body of the subjacent vertebra and the dislocated anterior masses anterior to the subjacent masses in this

configuration, the uncovered naked superior facets of the subjacent vertebra will be clearly evident.

MRI - determines the extent and type of spinal cord injury, presence of other intraspinal pathology, assess ligamentous and disc injury, also assess the status of posterior longitudinal ligament in retropulsion of the disc at the level of injury.

Myelogram - will show the extent of disc compression over the spinal cord, spinal nerves and the fragments compression the spinal cord.

TREATMENT PROTOCOL AND SURGICAL PROCEDURE

The goal of treatment of spinal cord injury-

1) Decompress neurologic elements

2) Preserve residual neurologic function

3) Avoid secondary injury

4) Restore spinal alignment

5) Restore spinal stability.

Initial Management:

1) Hard cervical collar, rigid spine board - at the scene of injury

2) Fluid & electrolyte management

3) Assess neurologic status

4) Methyl prednisolone if injury is <8 hours old. Dose - 30ml/kg in first 15 minutes

   5.4 ml/kg/hour infusion for next 23 hours.

5) Skull tong traction:

Gardner well tongs are inserted in line with the external auditory meatus, just 1-2 cm above the auricle. Weight of 5-10 pounds per interspace (for example - C4 fracture - 20 pounds, C5 fracture - 25 pounds) is applied. A repeat neurologic examination is performed and lateral radiograph is taken.

Indications for global stabilization include:

McAfee & Bohlman[23] -

- Compression flexion
- Burst fracture with posterior ligament involved
- Kyphotic deformity $>40^0$

Karl Schultz, Mark McLaughlin et al[17]

- Compression flexion
- Burst fracture
- Flexion distraction

Rockwood & Green[29]

- Teardrop fracture
- Burst fracture
- Severe subluxation & dislocation

Vaccaro[34]

- Teardrop flexion compression fracture

Ye X,Jian L et al[36]

- Multiple level cervical fractures

SURGICAL TECHNIQUE:

Lateral mass fixation with plate & Screws:

Position - Prone position on Stryker's frame (Fig.18).

Incision - Posterior midline exposure is used. Lateral masses of injured levels alone are exposed (Fig.19).

Fig.18: Prone Position on Stryker frame

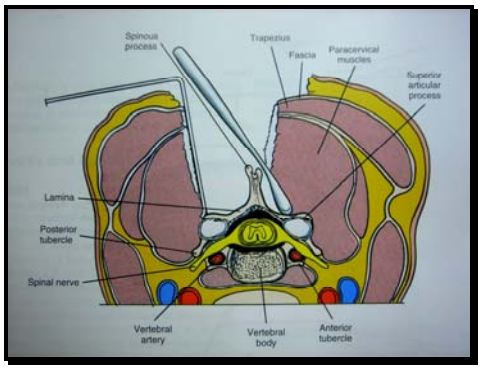


Fig.19: Lateral Mass Exposed

Reduction of subluxation or dislocation[29] (Fig.20)

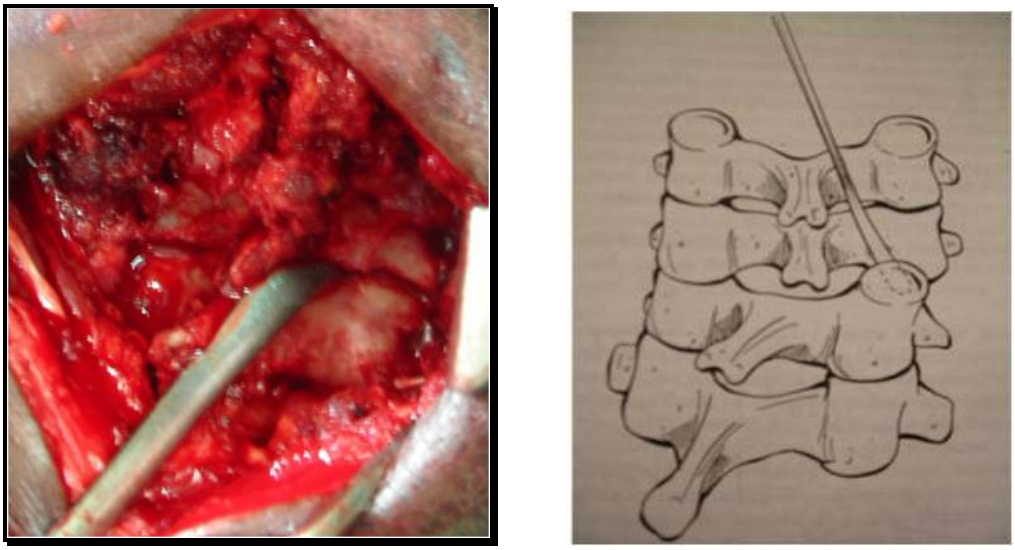


Fig.20 : Facetal unlocking

The spinous process can be manipulated as levers using Kocher clamps or towel clips. A small elevator, such as Freer, can be inserted into the dislocated facet joint and levered in an attempt to unlock the joint. If necessary, the cranial aspect of the superior facet can be removed with a burr to unlock the facet.

Screw insertion technique[29] (Fig.21)–

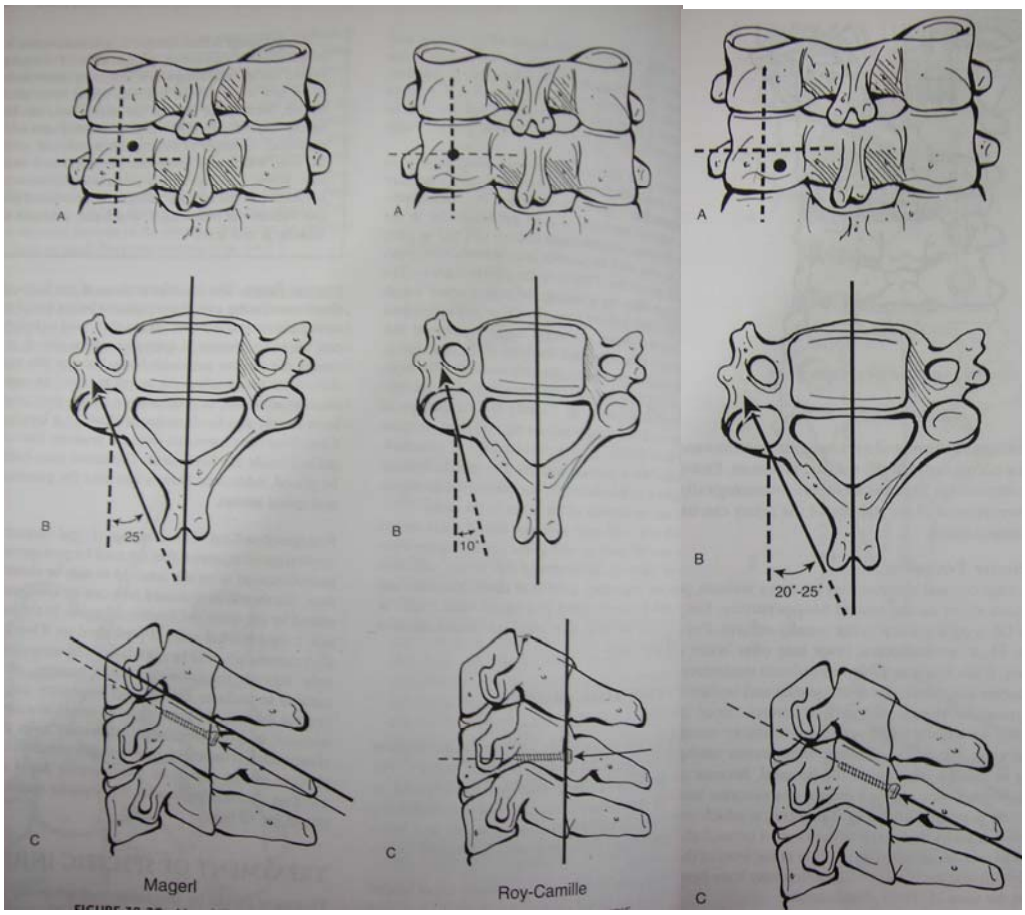


Fig.21:
Magerl Technique Roy-Camille Technique Modified Magerl Technique

Several techniques are mentioned. Roy-Camille, Magerl, An, Louis, Anderson - all have described their techniques. All these techniques vary from each other by the entry point and angulation of the screw. Currently modified Magerl technique is in vogue. Here entry portal is 1mm inferomedially to the centre of lateral mass directed 20^0 laterally and 30^0 superiorly. 3.5mm cortical screws with reconplate are used for fixation (Fig.22). Cancellous bone grafting is

done to augment fusion. Concerned articular surfaces are decorticated as well.

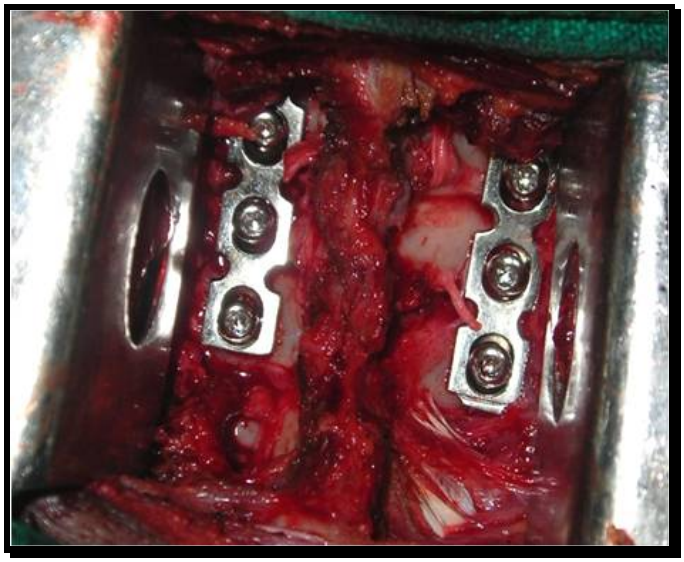


Fig.22: Lateral masses fixed with reconplates

Anterior decompression and stabilization:

(Same anaesthesia and same sitting)

Position - Patient is then turned supine on Stryker's frame with sandbag under interscapular region to induce hyperextension of neck, level of incision is marked by using landmarks already discussed.

Incision - Southwick Robinson approach[5] (Fig.23, Fig.24) is made by an oblique incision from anterior border of sternomastoid to the midline. Platysma and deep cervical fascia are divided. The plane passes between carotid sheath laterally and tracheo-esophagus

medially. Prevertebral fascia is stripped to expose longus colli muscles. Level is confirmed with fluoroscopy. Then discectomy is done. Corpectomy is done if necessary. Posterior longitudinal ligament is resected depending on whether it plays a role in neural compression.

Fig.23: Anterior incision

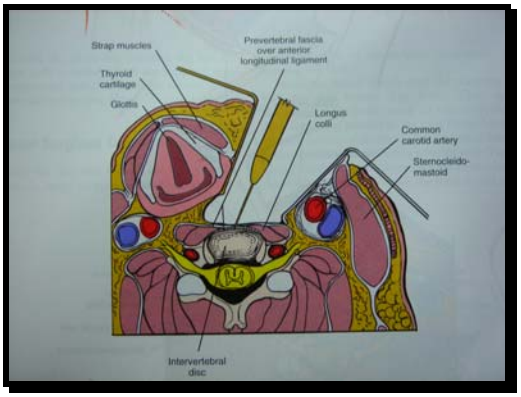
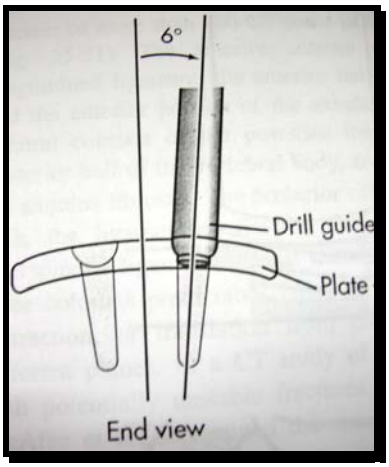


Fig.24: Soft tissue dissection

Autologous tricortical iliac rest graft or fibular graft is harvested and placed in the gap, after applying cervical traction.

Stabilisation is done with H-plate (Fig.25, Fig.26). Screws of length 14-16mm are used. They are directed toward midline at an angle of 6 degree in a convergent manner; & directed 15 degree cranially in cranial hole and 15 degree caudally in caudal hole. C-arm image intensifier is used whenever necessary (Fig.27)



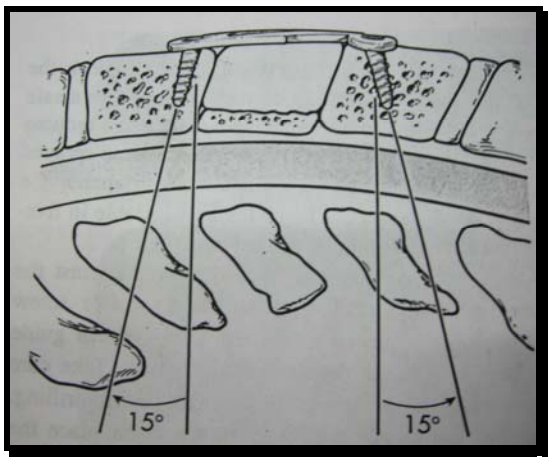


Fig.25:

Axial View *Lateral View*

Fig.26: H-Plate in-situ

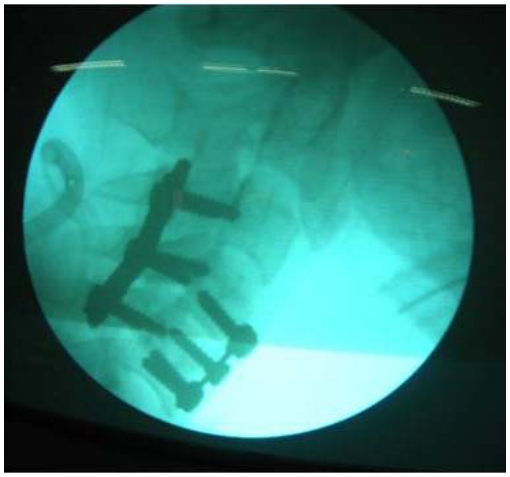


Fig-27: C-arm image intensifier

Postoperative protocol:

- Skull tongs removed on I post operative day.
- Drain removed on II post operative day.
- Patient is made to sit with philadelphia collar according to pain tolerance.
- Suture removal on 12th post operative day.
- Back, Bowel, Bladder care given.
- Philadelphia collar discarded after 6 weeks.
- X-rays taken periodically - immediate post operative, 2 weeks, 6 weeks, 12 weeks after surgery.

Documented complications in literature

McAfee et al[23]	***Schultz et al[17]***
1) Death	1) Myelopathy worsened
2) Horner's syndrome	2) CSF leak
3) Graft dislodgement	3) Dysphagia
4) CSF leak intra operatively	4) Hoarseness
5) Hypopharynx injury	5) Graft donor site infection
6) IJV injury & ligation	

7) Posterior wound dehiscence	

Apart from these, screw pullout, screwbreakage, plate breakage,esophageal fistula can occur.

MATERIALS AND METHODS

This is a prospective study of 16 cases of unstable subaxial cervical spine injuries at Government General Hospital, Chennai from May 2006 to October 2007.

Inclusion Criteria:

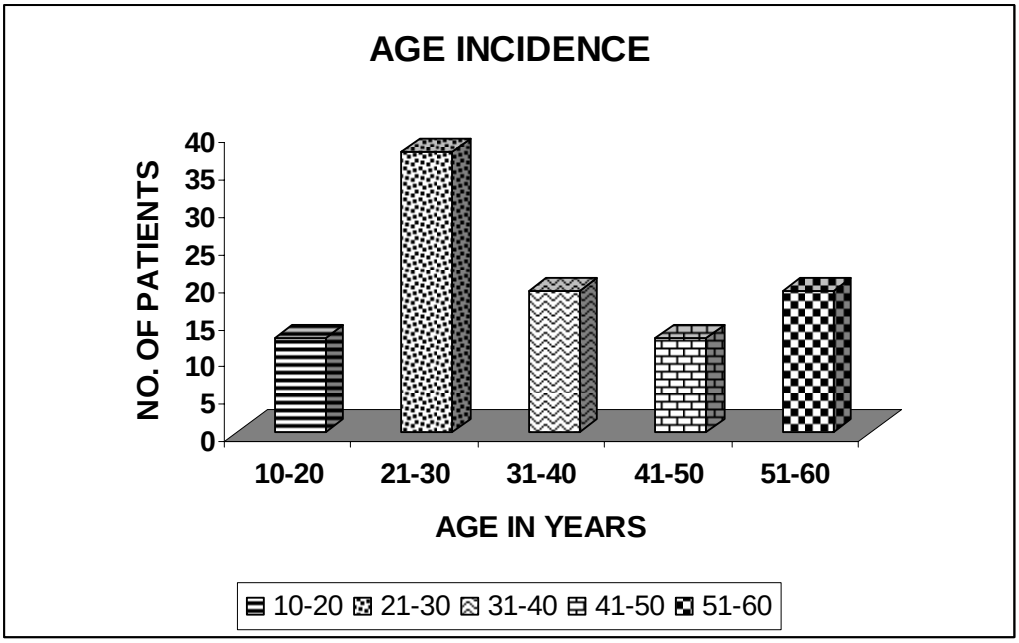
All unstable subaxial cervical spine injuries with more than one column involvement were included in this study.

Age Incidence:

Age of patients ranged from 13 to 59 years. Mean age was 36 years.

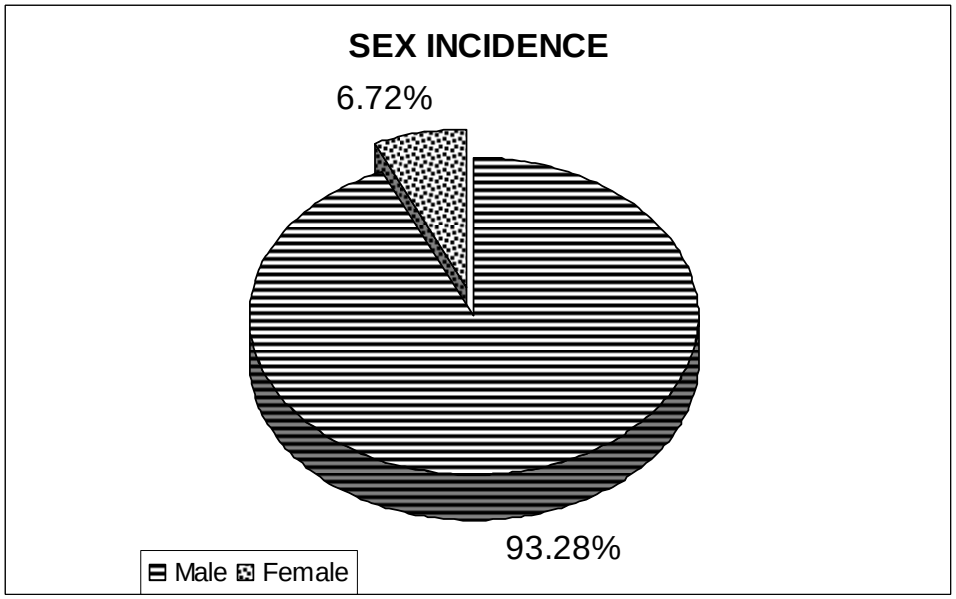
Table-1: Age Incidence

Age	***No. of patients***	***%***
10-20	2	12.5
21-30	6	37.5
31-40	3	18.75
41-50	2	12.5
51-60	3	18.75



Sex Incidence:

Sex	***No. of patients***	***%***
Male	15	93.75
Female	1	6.25



Mode of Injury:

TABLE 3:
MODE OF INJURY

Mode of injury	*No. of patients*	*%*
Fall from height	5	31.25
Fall with weight on back	3	18.75
Road Traffic Accident	6	37.5
Sea water diving	1	6.25
Hit by a bull	1	6.25

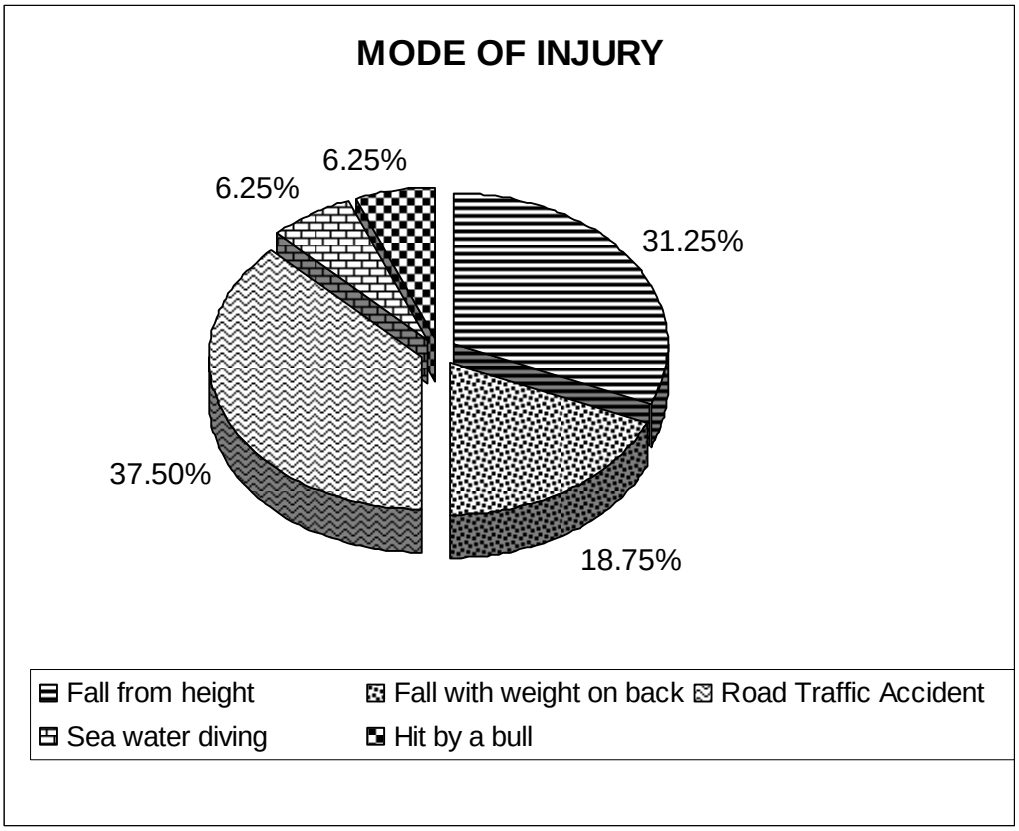


TABLE - 4
TYPE OF INJURY

Type of Injury	*No.of patients*
C5C6 subluxation with disc bulge with facetal locking	6
C4C5 subluxation with disc bulge with facetal locking	4
C6C7 body fracture	1
C6C7 subluxation with disc bulge with facetal locking	2
C3C4 subluxation with disc bulge with facetal locking	1
C5 burst fracture with C5 lamina fracture	2

According to Allen et al classification[29], 2 cases were compression flexion type & 11 cases were distractive flexion type.

TABLE 5:
CLASSIFICATION

Classification type	*No. of patients*
Compressive flexion	2
Distractive flexion	11
Vertical compression	3

TABLE 6:
NEUROLOGIC DEFICIT

Neurologic deficit	*No. of patients*
Complete	3
Incomplete	13

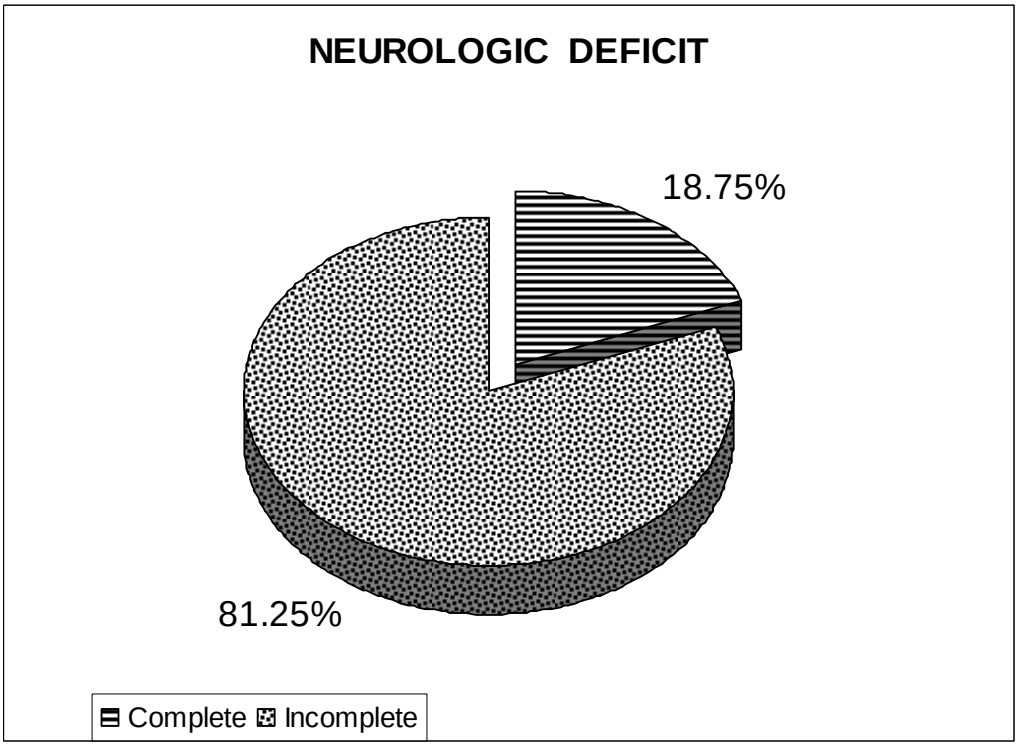


TABLE 7:
PREOP FRANKEL GRADE

Pre-op Frankel grade	*No. of patients*
A	3
B	1
C	11
D	0
E	1

TABLE 8:
TIME OF PRESENTATION

Time of presentation	*No. of patients*
Within 24 hours of injury	7
1 day - 1 week	6
1 week - 1 month	2
1 month - 3 months	1

Investigations:

Clinical signs were recorded. Basic blood investigation were done. Radiographs, CT scan and MRI were taken (which ever was indicated and feasible) to ruleout canal compromise, disc herniation, facetal instability.

Preoperative treatment:

Life supporting measures were taken. Skull tong traction applied immediately.

Anesthesia - Endotracheal general anesthesia administered.

TABLE - 9
PROCEDURE DONE

Procedure done	***No. of patients***
Lateral mass fixation posteriorly, and discectomy with plating anteriorly	12
C5 partial corpectomy with plating anteriorly and lateral mass fixation posteriorly	1
C5 total corpectomy with plating anteriorly and lateral mass fixation posteriorly	2
Discectomy with grafting anteriorly and lateral mass fixation posteriorly	1

SIDE FIRST APPROACHED

TABLE 10:

Side first approached	***No. of patients***
Anterior	5
Posterior	11

TIME INTERVAL:

Time intervals between admission and surgery was 4 days to 37 days.

BONE GRAFTS:

Autogenous tricortical iliac crest graft harvested from anterior crest and autogenous cancellous graft from posterior iliac crest were used in all cases.

IMPLANTS USED:

Recon plate and cortical screws for lateral mass fixation.

H-plate and cortical screws for anterior stabilisation.

LEVEL OF FUSION:

TABLE11:

Level of fusion	***No. of patients***
$C_4C_5C_6$	7
$C_3C_4C_5$	2
$C_5C_6C_7$	3
C_5C_6	1
C_3C_4	1
C_4C_5	1
$C_2C_3C_4$	1

Postoperative protocol:

- Skull tong removed on I post op day
- Drain removal on II post op day
- Mobilised with philadelphia collar on II post op day
- Suture removal on 12th post op day
- Philadelphia collar discarded after 6 weeks of surgery.

Follow up:

X-rays were taken immediate post op 2 weeks, 6 weeks and 12 weeks after surgery. Stress x-rays were taken after 12 weeks.

OBSERVATIONS

- In this study, majority of patients were in the age group of 21-30 years.
- There was a male pedominance in this study.
- RTA is the most common (fall from height being next most common) mode of injury.
- Most of the injuries presented within 24 hours of injury.
- Most of the patients had incomplete neurologic deficit.
- C5C6 subluxation with disc bulge with facetal locking was the most common spinal injury encountered.
- One case of 13 years male patient for whom anterior decompression and grafting was done without plating - to avoid growth arrest.
- Mean duration of fusion was 3 months.
- Mobilisation of neck started after 6 weeks.
- Complications-

  1.one patient developed posterior wound dehiscence - treated conservatively

  2.one patient developed sacral sore - managed conservatively.

- Frankel et al grading

TABLE - 12

Pre OP	Post OP					Total
	A	**B**	**C**	**D**	**E**	
A	–	2	1	–	–	3
B	–	–	–	–	1	1
C	–	–	3	5	3	11
D	–	–	–	–	–	0
E	–	–	–	–	1	1
Total	–	2	4	5	5	16

ANALYSIS OF RESULTS

Results were analysed during follow up using following criteria:

1) Pain
2) Neurologic recovery
3) Fusion status
4) stability of spine

The neurologic status was assessed using Frankel grading.

Type	***Characteristics***
A	Absent motor & sensory function
B	Sensation present & motor absent
C	Sensation present & motor active but not useful grade i.e. <3/5
D	Sensation present & motor active and useful i.e., ≥3/5
E	Normal motor and sensory function

The results are graded as follows:

Good:

- No neck pain

- Clear fusion mass at desired level
- Good stability of spine on stress X-rays
- Complete or partial neurologic recovery

Fair:

- Moderate neck pain which does not restrict day to day activities.
- No recovery of neurologic deficit
- Poor fusion mass
- Good stability of spine.

Poor:

- Severe neck pain
- No recovery or worsening of neurologic deficit
- Pseudoarthrosis
- Unstable spine

RESULTS

- Pain was absent in all cases
- Neurologic recovery noticed in most cases
- No neurologic detorioration
- Fusion achieved in all cases
- Stability of spine is good in all cases
- So, the grading of results is GOOD in all cases.

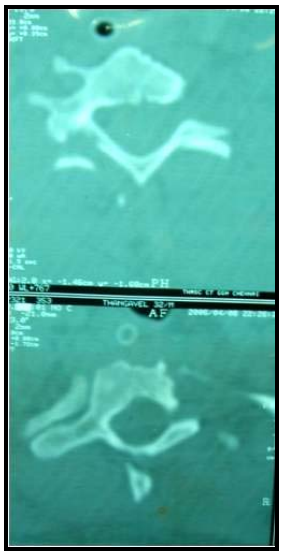
ILLUSTRATIVE CASES

CASE NO. 1 (FIG.28)**:**

Name	:	Thangavel
Age/Sex	:	32 yrs/male
Mode of injury	:	RTA
Preop Frankel grade	:	B
X-ray findings	:	C6C7 subluxation
CT scan	:	C6C7 bilateral facetal locking
Procedure done	:	Open reduction with lateral mass fixation posteriorly; and C6C7 disectomy, grafting, H plating anteriorly
Followup	:	14 months follow up showed good fusion and stability of spine.
Post op Frankel grade	:	E
Results	:	Good

Fig-28: ILLUSTRATIVE CASE-1

Pre-op Lateral View



CT Scan Axial View

Immediate Post Op lateral

Anterior scar

Posterior Scar

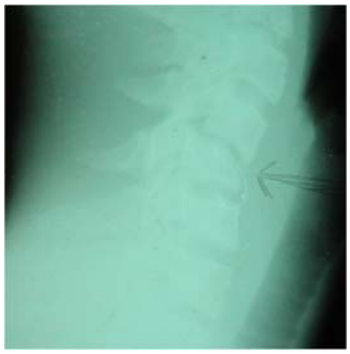
Fusion Achieved

Post-operative function

CASE NO. 2 (FIG.29)**:**

Name	:	Kannan
Age/Sex	:	23 yrs/male
Mode of injury	:	Diving into sea water
Preop Frankel grade	:	C
X-ray findings	:	C4C5 subluxation with compression fracture of C5
Procedure done	:	Lateral mass fixation posteriorly; C5 partial corpectomy, C4C5 dissectomy, grafting, H-plating anteriorly
Followup	:	9 months follow up showed good fusion and stability of spine.
Post op Frankel grade	:	E
Results	:	Good

FIG-29: ILLUSTRATIVE CASE-2



Pre-Op Lateral View

Immediate post-op AP & Lateral view

Post-OP mobilization & function

Fusion achieved

Stress view

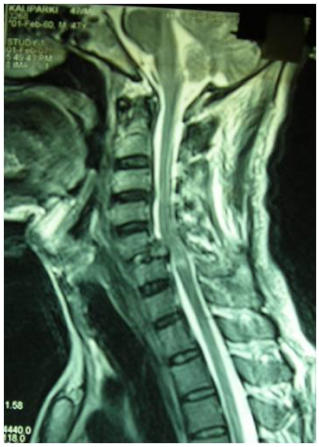
Neck movements

CASE NO. 3(FIG.30)**:**

Name	:	Kaliparki
Age/Sex	:	47 yrs/male
Mode of injury	:	Hit by a bull
Preop Frankel grade	:	C
X-ray findings	:	C5C6 subluxation
MRI Scan	:	C5C6 subluxation with locked Rt.facet
Procedure done	:	C5C6 discectomy, grafting and H-plating anteriorly, excision of Rt. superior articular facet of C6 (since reduction couldnot be achieved due to prior anterior fixation) and lateral mass fixation done.
Follow up	:	7 months follow up showed good fusion & stability of spine.
Post op Frankel grade	:	D
Results	:	Good

FIG-30: ILLUSTRATIVE CASE-3

Pre-Op lateral view



MRI Scan

Immediate Post-Op AP & Lateral View

Fusion achieved

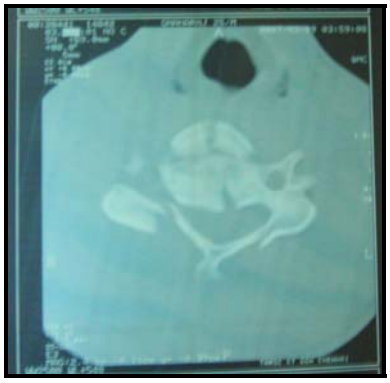
Stress View

CASE NO. 4 (FIG.31)**:**

Name	:	Gnanaraj
Age/Sex	:	25 yrs/male
Mode of injury	:	RTA
Preop Frankel grade	:	A
X-ray findings	:	Burst fracture C5
CT scan	:	Burst fracture C5 with B/L C5 lamina fracture
MRI Scan	:	Cord compression
Procedure done	:	C5 corpectomy, grafting, H-plating anteriorly, lateral mass fixation posteriorly.
Followup	:	7 months following showed good fusion and stability of spine. He developed sacral sore which got shrunken well with conservative therapy
Post op Frankel grade	:	C
Results	:	Good

FIG.31: ILLUSTRATIVE CASE-4

Pre-OP Lateral view



CT Axial View

MRI Lateral View

MR Myelogram

Immediate Post-OP AP

Lateral View

Stress View

Fusion Achieved

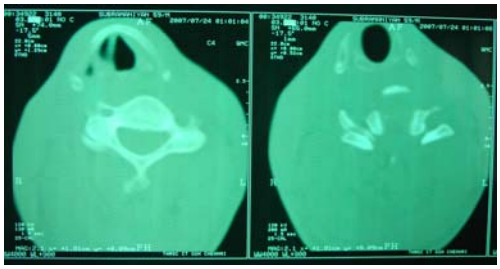
Rehabilitation

CASE NO. 5 (FIG.32)**:**

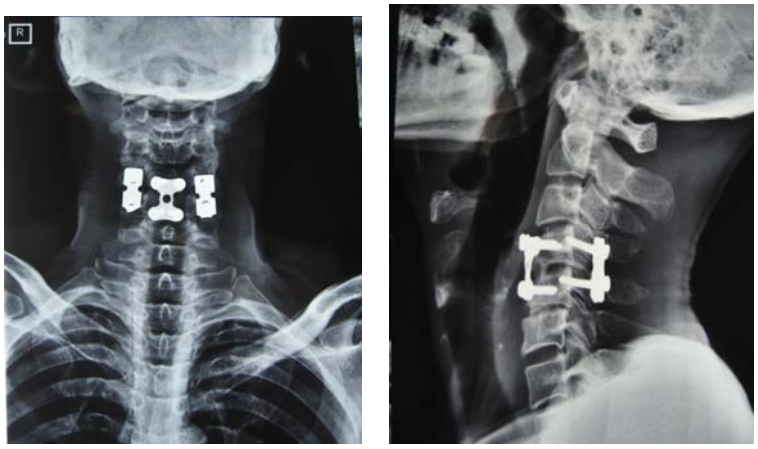
Name	:	Subramani
Age/Sex	:	59 yrs/male
Mode of injury	:	Fall from bench
Preop Frankel grade	:	C
X-ray findings	:	C4C5 subluxation
CTscan	:	C4C5 subluxation with facetal locking Right side
Procedure done	:	Lateral mass fixation posteriorly; C4C5 dissectomy, grafting, H-plating anteriorly
Followup	:	3months follow up showed good fusion & stability of spine.
Post op Frankel grade	:	D
Results	:	Good

FIG.32: ILLUSTRATIVE CASE-5

Pre-Op Lateral view



CT Axial view



Immediate Post-OP AP &Lateral view

Fusion achieved

Stress View

DISCUSSION

The most effective method for decompression, reconstruction and stabilitation of patients with complex cervical spine injuries remains controversial.

Although many authors have reported satisfactory results by using either the anterior or posterior approach alone, graft dislodgement, plate failure, pseudo arthrosis, progressive kyphotic deformities, and the halo-vest related complications remain significant concerns[17].

We believe that most degenerative cervical disorders can be addressed surgically with an isolated anterior or posterior approach. Our approach in patients with cervical spine injury has been to treat with combined anterior-posterior procedure that allows for decompression and restoration of sagittal alignment while providing immediate stability without the need for halo bracing. The term **circumferential arthrodesis**[22] has been used by McAfee & Bohlman (as early as in 1989) for this procedure.

Surgery on lower cervical spine injuries - predominantly done from anterior approach, because it is safe and effective - according to Kocis, Windsche et al[19].

Historically, posterior fixation and fusion has been the most popular method of internally stabilising the cervical spine after injury.

Failure to recognise the presence of ‘three column’ instability resulted in failure of posterior tension band stabilisation as a means of gaining cervical spine stability - according to Cybulski GR, Douglas et al[7].

Three column cervical spine instability is suspected in the presence of–

1) Retrolisthesis and angulation of superior vertebra on the next inferior vertebra.

2) Distraction of posterior interspinous ligaments sufficient to allow subluxation or dislocation of the facets; in conjunction with

3) A ‘shear’ dislocation of one vertebra over another.

Anterior shearing force through the disc space is capable of disrupting the intervertebral disc, along with disruption of anterior and posterior longitudinal ligaments, each contributing to the presence of anterior and middle column cervical spine instability.

Duration of surgery and general anesthesia - is 6.9 hours according to McAfee & Bohlman[23]. In our study it has been 3.5 hours.

Average blood loss in our study during the whole procedure is - 300ml (most of this loss occurs is posterior approach).

In our study, complication has been in the form of–

1) Wound dehiscence posteriorly - in one patient

2) Sacral pressure sore - in one patient.

In our study intercorporal fusion has been achieved in all cases. Stress x-rays were taken to confirm stability in all such cases.

Delayed extubation (Extubation beyond I post op day) - is related to operative time (>10.6 hours), crystalloid volume replaced (>6, 218 cm^3), blood loss (>2820 ml), blood replacement (>3.1 units)

- according to kwon B, Yoo Ju et al[20]. No such case in our study because of short operating time and less blood loss.

Which side first in Global Stabilisation?

- Posterior first approach - by Rothman & Traditional authors; Ye, Jian, Yuan et al (in B/L locked facets)
- Anterior first approach - by McAfee & Bohlman; Vaccaro; Ye X,Jian L etal.

Our experience:

We prefer posterior first in most cases because–

1) Axial & rotational correction can be done with less neurological damage.

2) Facetal unlocking is easier.

3) Anterior decompression done comfortably once alignment is obtained.

Anterior first approach has been done when–

1) C-arm image intensifier is not available - because reduction of any dislocation by posterior first approach causes difficulty in identification of correct vertebra level during anterior exposure.

2) Corpectomy and strut grafting is done - because posterior fixation first causes difficulty in distraction of adjacent vertebrae for graft placement & impaction.

Overall complication rate is combined procedure no greater than those with single anterior or posterior approaches - according to Schultz & McLaughlin et al[17]. We too support the same view.

CONCLUSION

- Single stage global stabilisation restores sagittal balance.
- Posterior stabilisation first achieves axial alignment than anterior first.
- Global stabilisation provides immediate rigid stabilization.
- Time taken is much less than staged procedure.
- Single anesthetic exposure.
- No deterioration of neurology in our study.

Therefore we consider single stage combined anterior and posterior stabilisation as a viable option in cervical spine injuries.

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MASTER CHART

S.No	Name	Age/Sex	IP No.	Mode of Injury	Diagnosis	Surgery Done	Which side first?	Complication	Outcome (Fusion)	Pre Op Frankel	Post Op. Frankel	Follow up duration
1.	Sugmar	30/M	822863	Slip & fall with wt. on back	C5C6 Sublux	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Died after 3 months not related to surgery	+	A	B	3 months
2.	Pandurangan	55/M	797158	Fall from tree	C5C6 Sublux	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	C	D	14months
3.	Kannan	23/M	849271	seawater diving	C4C5 sublux. with C5 compression#	LMF with BG-P C5partial corpectomy, Discectomy with BG with H-Plating A	Posterior	Nil	+	C	E	9 months
4.	Kanniyappan	28/M	861505	Fall from tree	C4C5 sublux with facet locked on lt with # C4 lamina	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	C	E	8 months
5.	Sheik	32/M	862582	RTA	C5C6 Sublux with C5 body #	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	E	E	8 months
6.	Sampath kumar	21/M	862927	Slip & fall with wt. on head	C5C6 Sublux with # C5 lamina lt	LMF with BG-P Discectomy with BG with H-Plating A	Anterior	Nil	+	C	E	8 months
7.	Durkasu	13/M	000989	Fall on back with wt on head	#C6C7 bodies with #C6 lamina lt	LMF with BG-P Discectomy with BG -A	Posterior	Nil	+	C	C	3 months
8.	Kaliparki	47/M	005563	Hit by a bull	C5C6 Sublux with locked facet Rt	Discectomy with BG with H-Plating A LMF with BG-P	Anterior	Nil	+	C	D	8 months

S.No	Name	Age/Sex	IP No.	Mode of Injury	Diagnosis	Surgery Done	Which side first?	Complication	Outcome (Fusion)	Pre Op Frankel	Post Op. Frankel	Follow up duration
9.	Arun	38/M	003671	RTA	C6C7 sublux with Hyperostosis with B/L locked facets	Bony bridge excised Discectomy with BG with H-plating -A LMF with BG-P	Anterior	Died of Aspiration pneumonia 3 months after surgery	+	C	D	2months
10.	Gnanaraj	25/M	015589	RTA	Burst # C5 with B/L lamina # C5	C5 corpectomy with BG with H-plating-A LMF with BG-P	Anterior	Nil	+	A	C	6 months
11.	Thangavel	32/M	799270	RTA	C6C7 sublux with B/L locked facets	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	B	E	14 months
12.	Kulanchi	45/M	040179	Fall from a tree	C5C6 Sublux with lt locked facet with #C5 spinous process	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	C	D	4months
13.	Panch-atcharam	52/M	043765	Fall from a tree	C3C4 sublux with C3 infr.facet # lt	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	C	D	4months
14.	Subramani	59/M	049308	Fall from a bench	C4C5 sublux with locked facet Rt	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	C	D	3 months
15.	Rooban Devaraj	24/M	058376	RTA	C4C5 sublux with C2C3 instability	LMF with BG-P Discectomy with BG with H-Plating A	Posterior	Nil	+	C	C	3 months
16.	Surya	19/F	059635	RTA	#C5 body and lamina with Retrolisthesis	Discectomy with C5 corpectomy with BG with H-plating-A LMF with BG -P	Anterior	Nil	+	A	B	3 months

ASIA

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

MOTOR

KEY MUSCLES

	R	L	
C2			
C3			
C4			
C5			Elbow flexors
C6			Wrist extensors
C7			Elbow extensors
C8			Finger flexors (distal phalanx of middle finger)
T1			Finger abductors (little finger)
T2			
T3			
T4			
T5			
T6			
T7			
T8			
T9			
T10			
T11			
T12			
L1			
L2			Hip flexors
L3			Knee extensors
L4			Ankle dorsiflexors
L5			Long toe extensors
S1			Ankle plantar flexors
S2			
S3			
S4-5			

0 = total paralysis
1 = palpable or visible contraction
2 = active movement, gravity eliminated
3 = active movement, against gravity
4 = active movement, against some resistance
5 = active movement, against full resistance
NT = not testable

☐ Voluntary anal contraction (Yes/No)

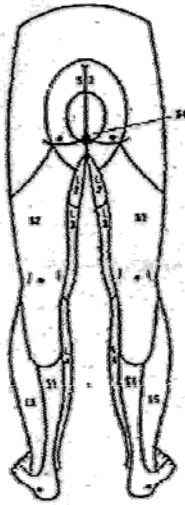
TOTALS ☐ + ☐ = ☐ MOTOR SCORE
(MAXIMUM) (50) (50) (100)

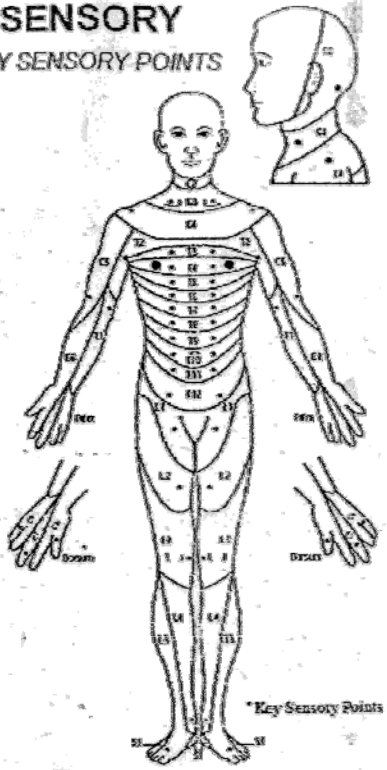
SENSORY

KEY SENSORY POINTS

	LIGHT TOUCH R	LIGHT TOUCH L	PIN PRICK R	PIN PRICK L
C2				
C3				
C4				
C5				
C6				
C7				
C8				
T1				
T2				
T3				
T4				
T5				
T6				
T7				
T8				
T9				
T10				
T11				
T12				
L1				
L2				
L3				
L4				
L5				
S1				
S2				
S3				
S4-5				

0 = absent
1 = impaired
2 = normal
NT = not testable





*Key Sensory Points

☐ Any anal sensation (Yes/No)

TOTALS ☐ + ☐ = ☐ PIN PRICK SCORE (max: 112)
(MAXIMUM) (56) (56) (56) (56)

= ☐ LIGHT TOUCH SCORE (max: 112)

NEUROLOGICAL LEVEL
The most caudal segment with normal function

	R	L
SENSORY	☐	☐
MOTOR	☐	☐

COMPLETE OR INCOMPLETE? ☐
Incomplete = Any sensory or motor function in S4-S5

ASIA IMPAIRMENT SCALE ☐

ZONE OF PARTIAL PRESERVATION
Caudal extent of partially innervated segments

	R	L
SENSORY	☐	☐
MOTOR	☐	☐